Doi: 10.61186/jorar.16.4.213

Vulnerability Assessment of Konarak City to Urban Floods

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Date of submission: 07 Feb. 2024 ***Date of acceptance: 02 Nov.2024***

Original Article

Abstract

INTRODUCTION: Since the presence or absence of various hazards in a geographical context is a relative matter, the resilience of cities to natural hazards is one of the important issues in urban planning and management; therefore, the objective of the present study is to assess the vulnerability of Konarak city to hazards caused by urban floods.

METHODS: In this descriptive-analytical study, field survey and a researcher-made questionnaire were used to collect data. The statistical population of the research included citizens living in Konarak city, 380 of whom were selected using the Cochran formula using a simple random sampling method. The data were analyzed with GIS software.

FINDINGS: According to the findings, the vulnerability of Konarak city to floods was assessed in terms of physical-infrastructural, social, economic, and institutional indicators in all neighborhoods. In the neighborhoods of Kalk Bazar, Surg, and Kohiyan, the physical-infrastructure index was higher than the average, which indicates the unfavorable condition of these neighborhoods in terms of physical conditions; socially, the lowest average was for Nazarabad and Surg neighborhoods; also, economically, the lowest average was for Nazarabad, Surg, and Baluchan neighborhoods, and institutionally, the lowest average was for Nazarabad, Surg, and Kohiyan neighborhoods.

CONCLUSION: The results showed that neighborhoods of Nazarabad, Surg, Baluchan, and Kohiyan have a very unfavorable situation in terms of environmental vulnerability, respectively, while neighborhoods of Zargaran, Kalk Bazar, and Saheli Markazi have a relatively more favorable situation.

Keywords: Urban vulnerability; Natural hazards; Urban flooding; Coastal city of Konarak.

How to cite this article: Asgari A, Arbabi Sabzevari A. Adibi Sa'adinejad F. **Vulnerability Assessment of Konarak City to Urban Floods**. Sci J Rescue Relief 2024; 16(3):213-220.

Introduction

Various natural disasters and accidents, such as flood, earthquake, landslide, avalanche, drought, etc., as well as man-made disasters, such as traffic accidents, plane crashes, industrial accidents, etc., are constantly occurring in different regions of the country which damage infrastructure, vital arteries, and facilities cause loss of assets, disruption of planning, increased mortality, and material and moral damages and injuries. One of these natural hazards that always threaten human settlements is torrential rains, which can cause extensive damage and casualties in a short period of time. (1) Flood is the most common natural hazard that is reported daily from most cities around the world and occurs in most environments, especially coastal, mountainous, and low-lying floodplain areas, and is more common in arid and semi-arid climates. Factors contributing to flooding include heavy rainfall, rapid snowmelt, sea level rise, steep slopes, infiltration rates, vegetation cover, dam failures (natural and artificial), urbanization, land use change, and deforestation. In order to prevent flooding and reduce subsequent consequences, urban managers need to predict rainfall characteristics, including peak intensity, arrival time, and duration, and warn residents of high-risk areas and take emergency measures to anticipate flooding. (2)

Flooding is a natural hazard that has complex direct and indirect geographical, economic, social, and ecological consequences, and unplanned urban

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growth and interventions in the natural flow of water usually increase the risk of urban flooding. (3) The occurrence of floods is a function of climatic events, especially the amount, intensity, spatial and temporal distribution of rainfall, and is also affected by various characteristics of the watershed, such as land use and human intervention. The increase in the impervious surfaces of the basin, which is caused by urban development and the construction of various structures on permeable soils, naturally reduces the amount of permeable surfaces that are able to absorb part of the rainfall. (4)

The southeastern coast of Iran, bordering the Sea of Oman, is occasionally and unusually affected by tropical storms, which are capable of producing large waves. In many areas along these coastlines, especially in the eastern and central parts, the waves from these storms constitute the dominant wave conditions for design, and the resulting surges cause flooding of coastal areas. (5)

Among the crises that have been occurring frequently in the region in recent years is the occurrence of tropical storms. A cyclone is an atmospheric disturbance characterized by strong winds and waves caused by its tides advancing along the coast, causing flooding, destruction of coastal areas including infrastructure, residential and agricultural areas, as well as death. The extent of damage from a cyclone depends on the height of the coast and its waves. In fact, it is very important to understand the city's vulnerability to the hazards of tropical rains and the resulting floods and to consider the necessary measures to adjust and adapt to climate change.

Arab Solghar et al. (2022) in a study concluded that the largest decreasing and increasing changes are related to the eastern and southwestern areas of the basin, respectively, and the largest and smallest changes were predicted based on the RCP8.5 and RCP2.6 scenarios, respectively. Therefore, considering the increase in temperature and precipitation, as well as the mountainous nature of the basin under study, it is necessary to consider flood control and management strategies. (6)

Panahi et al. (2022) concluded in a study that the Empirical Bayesian kriging (EBK) method can be evaluated can be evaluated as the best method used to estimate base changes and simulated rainfall for modeling flood trends along with other parameters. This method was the best method for interpolation in this study with the lowest average estimation error of 0.004 and root mean square error of 82.23. Also, in combining fuzzy analysis methods with hierarchy to determine the expected estimate, both methods had higher estimates than expected (7).

Bahrami et al. (2019) concluded in their study that the planning of the Kan River requires an approach that must be comprehensive and multidisciplinary, based on flood resilience considerations, and with an emphasis on landscape and ecological issues, it can serve as a model for other urban rivers that are vulnerable to flood disasters. (8) Nahid et al. (2010) showed in their study using WLC and AHP methods that districts areas 7 and 9 of Tehran city had a good physical resilience, but areas 1, 2 and 8 did not have a suitable condition. (9)

Panahi et al. (2021) concluded in a study that climate change and the structure of the natural environment in the region have resulted in consequences and effects such as changing precipitation patterns, creating heterogeneity in historical data series, changing river water levels and reducing agricultural production, changing the composition and plant production of pastures, changing groundwater levels, emerging social and economic problems, etc. (10) Khaledi et al. (2021) concluded that in terms of socio-cultural resilience, district 3 of Urmia city is the most desirable region with an average of 30.65 and district 6 is the most desirable region in terms of economy and management resilience with an average of 74.24 and 64.32. Also, in terms of physical resilience, region 4 is the most desirable region against flooding due to its better infrastructure facilities including access to medical centers, fire departments, hospitals, etc. (11)

Sapountzis and Kirkenidis (2022) showed in their research that human intervention in main streams, urban sprawl of wet Age-related Macular Degeneration (AMD) and sediment transport were among the main factors that that contributed to the flash flood generation. (12)

Mirasadollahi et al. (2020) concluded in a study that there is a significant relationship between all social and economic dimensions and the level of urban resilience to floods, and strengthening local organs and organizations in a decentralized state has been proposed as one of the important ways to increase the social participation of Gorgan citizens during a crisis. Also, by ensuring public participation and strengthening the economic empowerment of people during natural

[DOI: 10.61186/jorar.16.4.213]

hazards such as floods, people's initiative and creativity are strengthened and the scope for reducing damage caused by floods is reduced. (1)

A review of research conducted in the field of urban vulnerability shows the importance of this issue in dealing with natural hazards, including floods. Therefore, in this study, an attempt was made to assess the vulnerability of the city of Konarak to urban floods for the purpose of crisis management.

Location of the Study Area

The city of Konarak is located on the western shore of the Gulf of Chabahar and on the coast of the Sea of Oman. According to the new political divisions, this city has 2 districts: Zarbad and Markazi and 4 rural districts (Zarbad East, Zarbad West, Jahlian and Kahir). Although the maritime location of Konarak and its location at the mouth of the Gulf of Chabahar make the climate of this city different from other cities in Sistan and Baluchistan province (except Chabahar) and this city, especially in summers, benefits from the warm and humid front of the Indian Ocean and its monsoons, it still receives its winter and autumn rainfall from the western and northern systems that affect most parts of the country. In general, the climate of the city depends on factors such as climatic elements and climatic factors, because climatic factors have direct and indirect effects on the formation of the climate and weather conditions of the region. Given the specific geographical location of Konarak, the influence of the southeast monsoon system and summer storms such as Gonu and similar ones can be problematic and dangerous if they come as a surprise and attack suddenly. Also, the occurrence of severe earthquakes on the seabed or in the Indian Ocean (in the vicinity of the region) can put all urban facilities, places and buildings at risk of destruction by creating destructive, high and terrifying tsunami waves. Especially since an urban area such as Konarak is on a slope and at an altitude of between 1 and 10 meters above the open sea level, it is completely vulnerable and defenseless (13).

Methods

In this descriptive-analytical study, Delphi technique and environmental scanning use to identify variables and indicators. Library-documentary studies, internet resources, observation, upstream documents and urban plans in Konarak regarding the occurrence of urban floods were first used to obtain data. In order to examine the current situation of the study area, the required data was collected through field visits and surveys and by referring to organizations and departments. Therefore, to examine the status of the level of environmental vulnerability of Konarak city, it was measured in the form of four indicators: physical-infrastructural, economic, social and institutional.

In this regard, a researcher-made questionnaire, whose items were derived from the results of qualitative data analysis and the experts' opinions familiar with the subject was prepared based on a five-option Likert scale and appropriate for the population of 8 neighborhoods of the city and randomly distributed to the citizens of Konarak. Next, 380 people were selected using the Cochran formula. Then, in order to spatialize the data obtained from the questionnaire based on the address, coding was performed in GIS software, and finally all variables were plotted spatially and in the form of a map. The research process in this section was as follows: in order to identify and zone the resilient spaces of Konarak city, first, in addition to the existing data for some indicators, a questionnaire was used for some other indicators for which no data was available and were important in resilience, and local experts in Konarak city were asked for their opinions. In the next neighborhood, maps of the city's vulnerability to flooding were prepared for each indicator using spatial analysis functions.

Findings

In the *physical-infrastructure index*, physical measures and infrastructure problems of relevant institutions such as Municipality were examined regarding flood prevention. The results of the Konarak city survey show that the Nazarabad, Surg, and Kohiyan have the most physical problems among other neighborhoods. According to the surveys, the southern neighborhoods of the city, due to the location of worn-out textures and the initial core of the city, have many physical problems such as the lack of surface water collection channels, asphalt roads, earthen roads, etc.

The results obtained from the survey of physical measures show that in the northern neighborhoods such as Zibashahr have fewer physical problems due to their new establishment. In addition, in the eastern neighborhoods such as Saheli Markazi and Kalk Bazaar, the most physical measures have been taken regarding flood prevention and tropical

[DOI: 10.61186/jorar.16.4.213]

storms (tsunamis). The surveys also show that the least physical measures have been taken to prevent floods in the Nazarabad neighborhood.

In order to determine the physical-infrastructure index in Konarak city, all the sub-criteria of this index (physical measures and problems) were combined in GIS and finally the status of the physical-infrastructure index was determined.

The results show that the neighborhoods of Kohiyan, Kalk Bazaar, Surg and Nazarabad have an unfavorable physical and infrastructure situation, and the neighborhoods of Baluchan and Zibashahr have a more favorable situation. Figure 1 shows the status of the physical-infrastructure index in Konarak city.

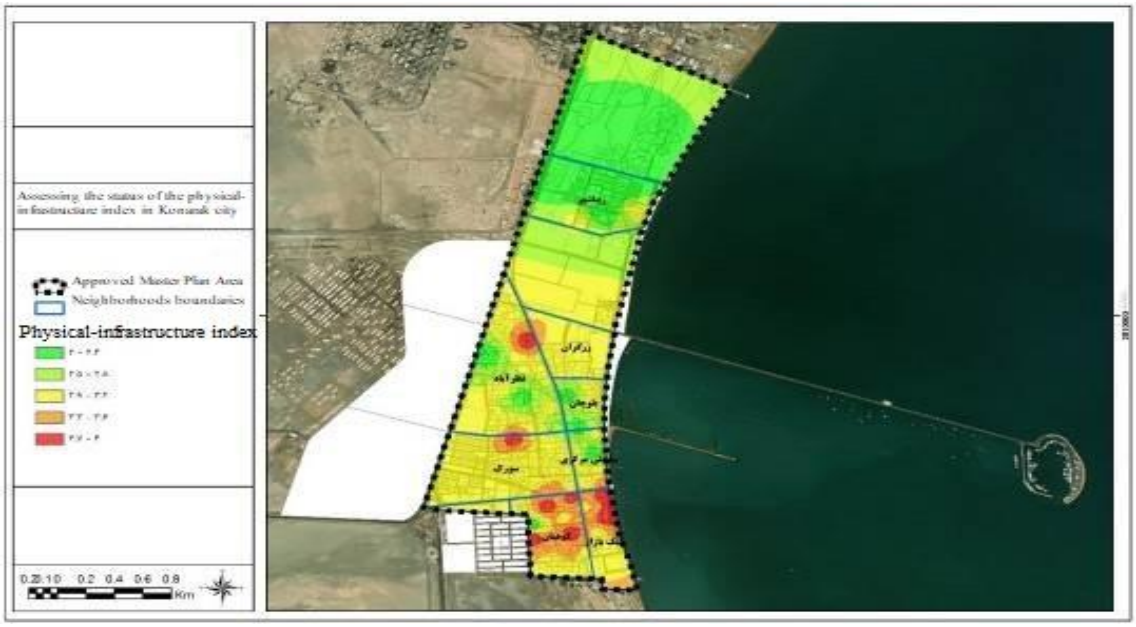

Figure 1. Assessing the status of the physical-infrastructure index in Konarak city

Figure 2. Assessing the status of the social index in Konarak city

The *social* index examined the following criteria: a) the level of public education on unexpected events and natural hazards such as flood and storm by relevant institutions; b) the level of education on first aid during floods by relevant institutions; and c) the level of knowledge

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of risks and familiarity with crisis management during disasters such as flood. The results show that the lowest level of public education has been carried out in Nazarabad and Surg neighborhoods.

In order to determine the economic index in Konarak city, all the sub-criteria were examined and finally combined in GIS. According to the results, the status of the economic index in the neighborhoods of Konarak city is very unfavorable, as in the neighborhoods of Nazarabad, Surg and Kohiyan is more significant.

Figure 2 shows the status of the social index in Konarak city.

In the *economic* index, the criteria examined as follows: a) the financial status of the household at the time of flood risks in order to compensate for the damages caused by it; b) the level of financial capability to renovate or retrofit the building against natural hazards such as floods; c) the level of access and use of facilities to retrofit and renovate the building; and d) the level of familiarity with insurance against accidents caused by natural hazards such as flood, storm, etc.

The results indicate that residents of Nazarabad, Baluchan, and Kalk neighborhoods have low financial capacity and little access to financial facilities from Banks to renovate or retrofit their buildings against natural hazards such as floods, but they are in an average position compared to other neighborhoods in the city.

In order to determine the economic index in Konarak city, all the sub-criteria were examined and finally combined in GIS. The results obtained show that the economic index situation in the neighborhoods of Konarak city is very unfavorable, as in the neighborhoods of Nazarabad, Surg and Kohiyan, the unfavorable economic situation is more significant.

Figure 3 shows the economic index situation in Konarak city.

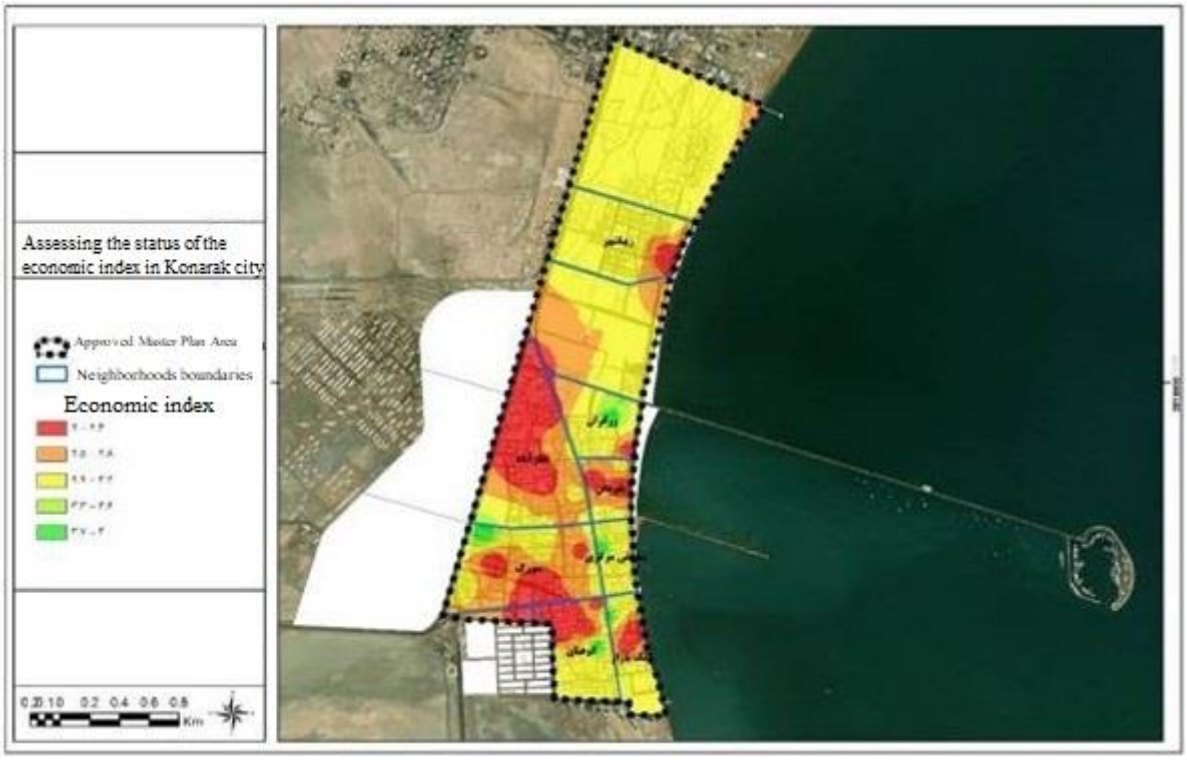

Figure 3. Assessing the status of the economic index in Konarak city

Table 1. Average environmental vulnerability in Konarak city by neighborhoods

Name of neighborhoods	Kohiyan	Saheli Markazi	Baluchan	Surg	Kalk Bazaar	Zibashahr	Zargaran	Nazarabad
Vulnerability	2/63	2/78	2/55	2/42	2/72	2/61	2/86	2/25

[DOI: 10.61186/jorar.16.4.213]

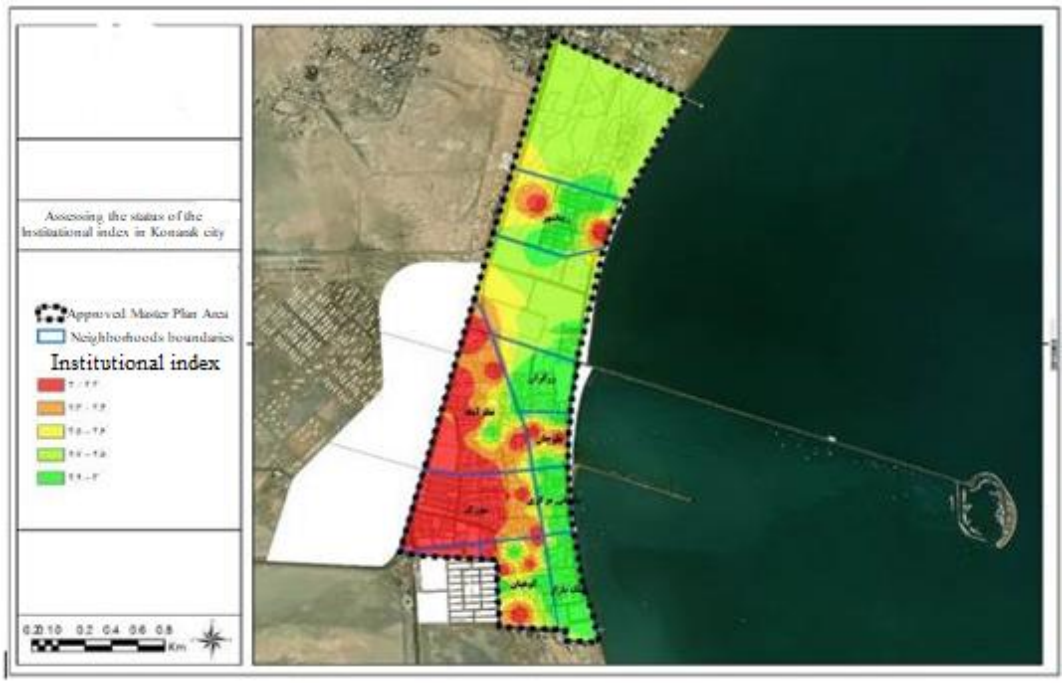

Figure 4. Assessing the status of the institutional index in Konarak city

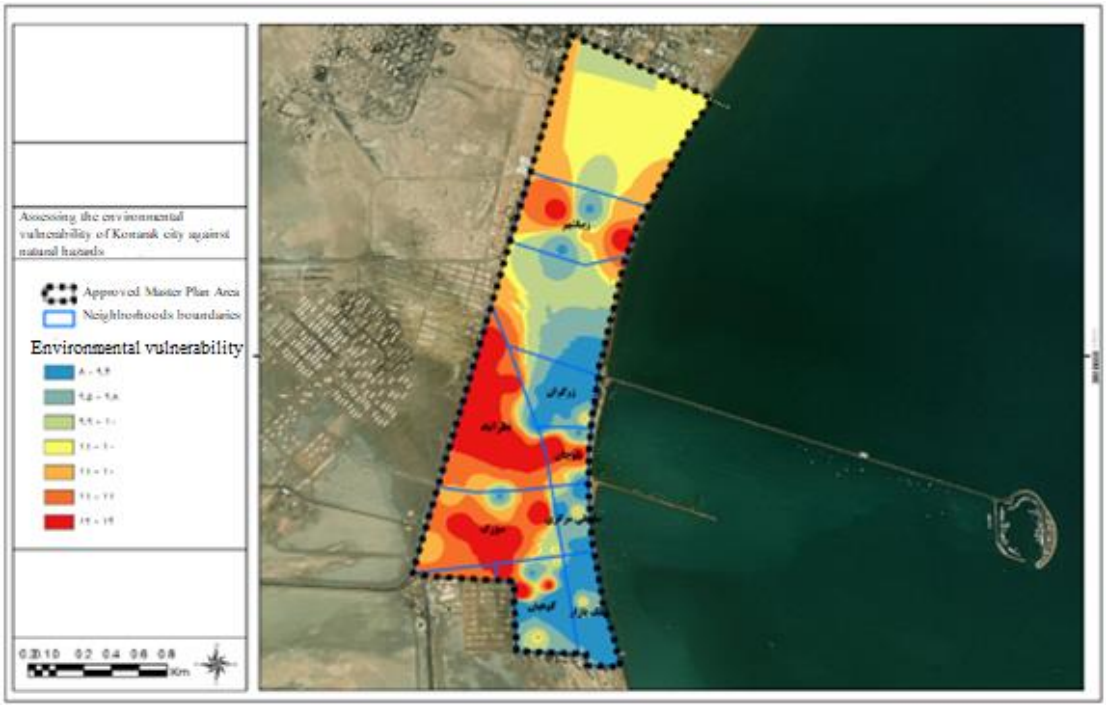

Figure 5. Distribution of environmental vulnerability of Konarak city against natural hazards

In the *institutional* index, these criteria were examined: a) the level of recognition and awareness of organizations related to unexpected events and crisis management; b) the level of actions in the field of maneuver and preparedness against natural disasters by relevant institutions such as the Municipality, relief centers, etc.; c) satisfaction with the performance of institutions effective in reducing the effects of natural disasters such as floods and storms; and d) the extent of crisis management relief facilities and services (Fire Department, Red Crescent Society, Emergency Department, Police Force, etc.) during floods.

The results show that in Nazarabad and Surg neighborhoods, the level of recognition and

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awareness of organizations related to unexpected events and crisis management is low. Also, the studies indicate that in parts of Zibashahr, Zargaran, and Saheli Markazi neighborhoods, the level of recognition and awareness is high.

Findings of the level of actions taken in the field of maneuver and preparedness for natural disasters by relevant institutions such as the municipality, relief centers, etc. in the city of Konarak show that the level of preparedness of relief institutions is equal among the city's neighborhoods.

The results obtained from examining the level of satisfaction with the performance of institutions effective in reducing the effects of natural disasters such as floods and storms in the city of Konarak show that the level of satisfaction is low in parts of the neighborhoods of Nazarabad, Surg, Zargaran, and Kohiyan while in parts of the neighborhoods of Zibashahr, Kalk Bazaar and Saheli Markazi, the level of satisfaction with the performance of institutions is high.

In order to determine the institutional index in Konarak city, all the sub-criteria of this index were combined in GIS. According to the results, the neighborhoods of Nazarabad, Surg, and Baluchan have a very unfavorable institutional situation while the neighborhoods of Zargaran, Kalk Bazaar, Saheli Markazi, and Zibashahr have a relatively more favorable situation.

Figure 4 shows the status of the institutional index in the city of Konarak.

Discussion and Conclusion

Konarak is one of the southeastern coastal cities of the country, which has faced signs of climate change caused by torrential rains and floods in recent decades and has experienced risks in recent years. In dealing with the risks caused by floods that have caused great damage to residents, increasing resilience is of interest.

Resilience is an integrated approach to improving existing capacities and reducing the vulnerability of human societies in dealing with various crises and natural hazards. In fact, resilience is not only summarized in making buildings resistant, but understanding this concept and familiarity with its solutions precedes the body, and this provides the grounds for increasing resilience in all dimensions. The present study, with a different and comprehensive approach, in addition to examining the dimensions of resilience, assessed the vulnerability of neighborhoods in Konarak.

This study, in line with Nahid et al. (2021), Panahi et al. (2021), Khaledi et al. (2021), and Mirasadollahi et al. (2020), examined the importance of physical, economic, social, and institutional indicators in the study area. In this study, it was concluded that most of the neighborhoods of Konarak County are not in a favorable condition in terms of resilience to natural hazards, especially floods, in the aforementioned indicators, and therefore, the vulnerability assessment of Konarak City should be considered. Due to its specific geographical conditions, Konarak is forced to have resilience and readiness to avoid any damage caused by flooding rains. Konarak is a city stretching from south to north and formed on a flat surface, as a result of which the groundwater level is high, and the absorption wells that were installed to dispose of wastewater create many problems for the residents of their neighborhoods during rainfall. The construction of the city's boulevard and beltway by the Road and Urban Development Department has also caused a change in the direction of the slope from the sea to the coast, which causes flooding during floods. Therefore, to avoid flooding, its underground drainage network must be west and east so that the water from rainfall is drained towards the sea. (Figure 5)

In order to measure environmental vulnerability in Konarak city, physical-infrastructural, social, economic and institutional indicators along with their examined sub-criteria were combined in GIS, and finally environmental vulnerability was determined by neighborhoods of Konarak city. The results of this study showed that the physical-infrastructural index in the neighborhoods of Kalk Bazar (3.17%), Surg (3.06%) and Kohiyan (3.19%) is higher than the average (average 3), which indicates the unfavorable condition of these neighborhoods in terms of physical- infrastructural conditions. The lowest average in the social index is related to the neighborhoods of Nazarabad (1.62%) and Surg (1.63%), which indicates the unfavorable condition of these neighborhoods in terms of social conditions. The lowest average in the economic index is for the neighborhoods of Nazarabad (2.18%), Surg (2.66%), and Baluchan (1.56%), which indicates the unfavorable economic situation of these neighborhoods. Also, the lowest average in the institutional index is for the neighborhoods of Nazarabad (2.36%), Surg (2.34%), and Kohiyan (2.5%), which indicates the

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unfavorable institutional situation of these neighborhoods. Overall, the results show that the neighborhoods of Nazarabad, Surg, Baluchan, and Kohiyan have a very unfavorable situation in terms of environmental vulnerability, respectively, and the neighborhoods of Zargaran, Kalk Bazaar, and Saheli Markazi have a relatively more favorable situation. (Table 1)

Compliance with Ethical Guidelines

All ethical principles have been considered in this article, and participants were informed of the purpose of the research and its implementation steps.

Funding/Support

This article is extracted from Ebrahim Frouzanmehr PhD thesis entitled "Vulnerability Assessment of Konarak City to Urban Floods" without financial support from Islamshahr Branch Islamic Azad University, Tehran.

Author's Contributions

This article is based on Ebrahim Frouzanmehr PhD thesis at Islamshahr Branch Islamic Azad University of Tehran, who was responsible for conducting the research, collecting, and analyzing the data; and Azadeh Arbabi Sabzevari, the second author was responsible for the design and supervision, and Fatemeh Adibi Sa'adinejad was responsible for the methodology. However, Frouzanmehr and Sabzevari were responsible for correspondence and editing the final manuscript submitted to the journal.

Conflict of Interests

The authors declare no conflict of interest.

Acknowledgments

The authors hereby acknowledge all those who contributed to this research.

Acknowledgments

The authors would like to express their gratitude to all participants in this study.

Conflict of Interests

The authors declare no conflict of interest.

References

1. Mirasadollahi S, Motevali S, Janbaz Ghobadi GH. [Analysis of the resilience of urban settlements against flooding with emphasis on economic and social indicators (case study: Gorgan city) (Persian)]. Journal of Applied Research in Geographical Sciences, 2020; 20(59): 137-157.
2. Yanzhen, K. Xindong, O. Shigong, W. Chunqing, D. Kezheng, S. And Yang, Z. Statistical characteristics and synoptic situations of long-duration heavy rainfall events over North China. Earth And Space Science. 2022:1-18.
3. Douglas I., Alam K., Maghenda M. et al. Unjust waters: climate change, flooding and the urban poor in Africa. Environment and Urbanization. 2008; 20(1): 187-205
4. Khaledi S., Ghahroudi Tali M., Farhamand Q. [Measuring and evaluating the resilience of urban areas against urban floods (case study: Urmia city) (Persian)]. Journal of Geographical Environment Sustainable Development, 2019; 1(2):1-15.
5. Karimi J, Shoushtrizadeh Naseri A. [Evaluation of the accuracy of coastal flood risk estimation maps using digital elevation model (DEM) of the studied area: southeast coasts of Iran (Sistan and Baluchistan province) (Persian)]. 10th International Conference on Coasts, Ports and Structures Marine, Tehran. 2013.
6. Arab Solghar A.A, Porhemmat J., Goudarzi M. [Predicting climate change using atmospheric general circulation models and downscaling of SDSM and LARS-WG models under radiative forcing scenarios in the Dez River Basin. (Persian)]. Journal of Physical Geography. 2022. 15(55):129-149.
7. Panahi A., Janbaz Ghobadi GH., Motevali S, Khaledi SH. [Modeling and predicting the risk of regional occurrence of floods due to precipitation under climate change conditions (case study: Gorganrood watershed) (Persian)]. Journal of Physical Geography, 2022;15(56):17-38.
8. Bahrami F., Alehashemi A., Motedayen, H. [Urban rivers and resilience thinking in the face of flood disturbance, the resilience planning of the Kan river (Persian)]. MANZAR, the Scientific Journal of landscape, 2019; 11(47): 60-73. http://doi.org.10.22034/manzar.2019.182617.1948
9. Nahid M, Zand Moghadam M, Karke Abadi, Z. [Measuring and evaluating resilience against the risk of urban floods (case study: district 4 of Tehran) (Persian)]. Pasture and Watershed Management (Natural Resources of Iran), 2021;74(1): 189-205.
10. Panahi A., Janbaz Qobadi G., Motevali S., Khaledi S. [Measurement and Prediction of the Potential Occurrence of Floods Under Climate Change Conditions (Case study: Gorganrood watershed) (Persian)]. Geographical Studies of Coastal Areas Journal. 2023; 4(2): 45-61. http://doi.org.10.22124/gscaj.2023.22411.1172
11. Khaledi S., Ghahroudi Tali M., Farhamand Q. [Measuring and evaluating the resilience of urban areas against urban floods (case study: Urmia city) (Persian)]. Geographical Environment Sustainable Development Quarterly, 2022: 2(3): 169-182.
12. Kastridis A., Kirkenidis C., Sapountzis M. An integrated approach of flash flood analysis in ungauged Mediterranean watersheds using post-flood surveys and Unmanned Aerial Vehicles (UAVs). Hydrological Processes. 2022; 34 (25): 4920-4939.
13. [Mani Matin Homeland of Mehrestan (Baluchistan) (Persian)]. Konarak County. [Internet]. Sistan & Baluchistan: Iran; 2012 [cited 24 May 2012]. Available from:/https://kuhe-birk.blogfa.com/post/ 32

[DOI: 10.61186/jorar.16.4.213]